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DESIGN AND PERFORMANCE OF THE PETAWATT LASER SYSTEM

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ABSTRACT

We recently demonstrated the production of 1.25 PW of peak power in the Nova/Petawatt Laser Facility, generating >500 J in 430 fs. Recent experiments on active beam control and targeting system producing > 10^{21} W/cm^2 will be described.

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We recently demonstrated the production of over a petawatt of peak power in the Nova/Petawatt Laser Facility, generating >500 J in 430 fs. The Petawatt Laser Project was initiated to develop the capability to test the fast ignitor concept[1] for inertial confinement fusion (ICF), and to provide a unique capability in high energy density physics. The laser was designed to produce near kJ pulses with a pulse duration adjustable between 0.5 and 100 ps and a focused irradiance in excess of 10^{21} W/cm^2.

The laser system begins with a Ti:sapphire chirped pulse amplification system operating at 1054 nm. The pulse is stretched to ~ 3 ns and is amplified up to 50 mJ in the titanium-sapphire section with minimal bandwidth narrowing. Further amplification in mixed phosphate glass rod amplifiers produces a spectrally-shaped 12 J pulse. This pulse is further amplified up to the near kilojoule level by a series of disk amplifiers. Near diffraction-limited beam quality is achieved by utilizing only the central 80% of the disk amplifiers and the use of adaptive (deformable) optics to correct any residual thermal or pump induced aberrations. Following amplification, the chirped nanosecond pulse is compressed to 480 fsec by a pair of large aperture diffraction gratings arranged in a single pass geometry. Pulse compression occurs in vacuum with a compressor throughput of 84%. Currently, this system is limited to 600 J pulses in a 46-cm beam. Expansion of the beam to 58 cm with the installation of 94-cm gratings will enable 1 kJ operation.

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[1] M. Tabak, et. al., Phys. Rev. Lett. (1994)

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Target experiments with petawatt pulses will be possible either integrated with the Nova 10 beam target chamber for fast ignition experiments, or as a stand alone system in an independent chamber. Focusing the beam onto a target is accomplished using an on axis parabolic mirror. The focal spot is diagnosed with an optical imaging system, as well as an axial x-ray imaging camera. Since debris from target experiments would put the parabola at risk, a secondary "plasma" mirror is used in conjunction with the parabola to focus the beam on target. For irradiances > 10^{14} W/cm^2, short pulse radiation creates a critical density plasma on the surface of a dielectric substrate, with a demonstrated reflectivity > 90%.[2] For incident pulses on the order of 500 fs, the plasma has insufficient time to undergo hydrodynamic expansion, producing a density scale length less than the incident wavelength. This novel targeting system will enable the production of ultrahigh contrast pulses, with an easily variiable effective focal length by changing the curvature of the secondary mirror.

Figure Caption

Figure 1: a) Far-field distribution of the beam from the front-end of the Petawatt laser after reflecting from a polished SiO_2 surface. The central spot is diffraction-limited.
b) Same as fig 1a but after reflecting from the plasma mirror at 90% reflectivity.

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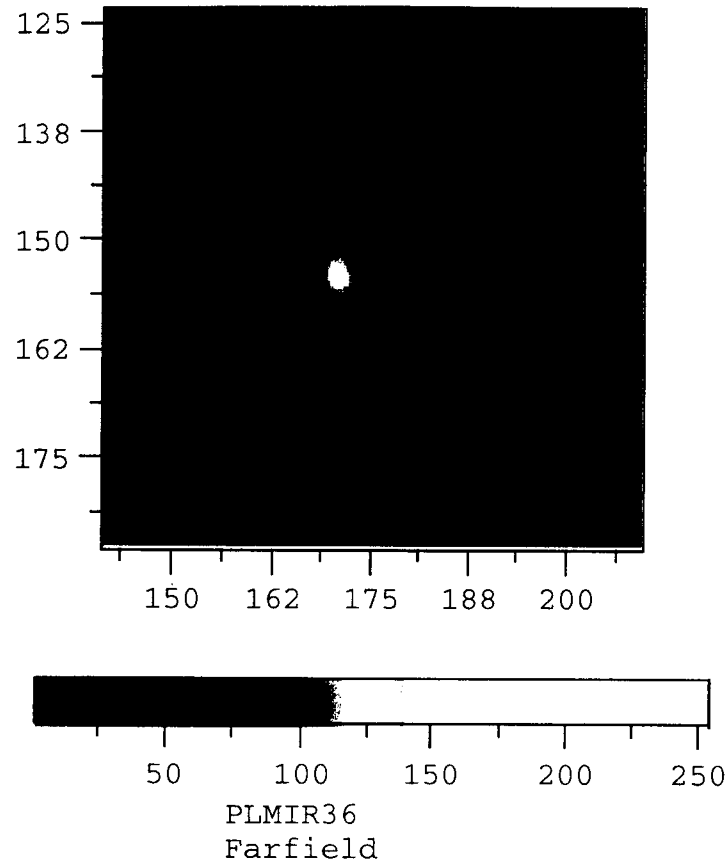
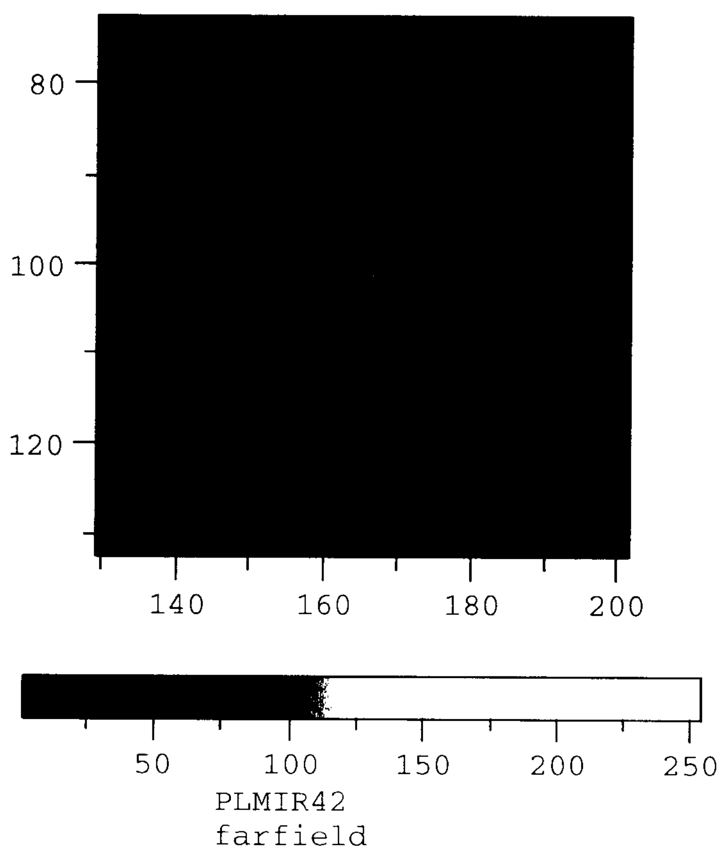
[2] M. Perry, et. al., submitted to (1995)



125
138
150
162
175
150
162
175
188
200
50
100
150
200
250
PLMIR36
Farfield

a)



80
100
120
140
160
180
200
50
100
150
200
250
PLMIR42
farfield

b)